Constraints on the Venus Deep Atmosphere Composition from Near Infrared Observations of the Night Side

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Spatially-resolved NIR images and spectra of Venus obtained in 1983 revealed high-contrast emission features on the night side of the planet at wavelengths near 1.74 and 2.3 μm. Subsequent observational and modeling studies confirmed that this radiation originates as thermal emission from the hot lower atmosphere (25 40 km). The horizontal contrasts are produced as it escapes through regions of the H_2SO_4 clouds that have different opacities. Preliminary efforts to analyze NIR observations confirmed their value for studies of the deep-atmosphere composition. However, the modest spectral resolution of the early measurements, combined with shortcomings in the existing radiative transfer models and spectral databases for gases initially precluded accurate estimates of trace gas mixing ratios below the clouds. The first high-resolution near-infrared spectra of the Venus night side were taken in November 1989. These spectra revealed H_2O mixing ratios of ~30 ppmv just below the clouds, and confirmed D/H ratios 12?()-tiltl(w greater than those on Earth. These spectra also provided improved constraints on the mixing ratios of CO, HF, HCL, SO_2, and OCS below the clouds. Ground-based observations taken on 29 January 1990 revealed large horizontal variations in the H_2O mixing ratios just 1)(:-IOW the cloud base. Because the largest H_2O amounts (200" ppm) were associated with a region of anomalously-low cloud optical depth, they were interpreted as evidence for subsidence, evaporation, and thermal dissociation of H_2SO_4 cloud droplets. This H_2O anomaly had vanished 1)('[01"(" the Galileo spacecraft flew past Venus 011 1 () February. However, the Galileo NIMS observations indicated significant meridional variations in CO. Observations taken in February 1990 also revealed new spectral windows at 1.0, 1.1, 1.18, 1.27, and 1.31 μm. The 1.0, 1.1, and 1.18 μm windows probe the lowest scale height and reveal emission contrasts associated with surface temperature variations. Weak water vapor lines in these windows provide the best available constraints on the near-surface water abundances. A combined analysis of spectra taken in all of the NIR windows indicates that the H_2O mixing ratios increase from ~20 ppm at the cloud base (~47 km) to about 45 ppm at 30 km altitude, and then remain constant between that level and the surface. Recent reanalyses of in-situ water vapor measurements taken by the Pioneer Venus and Venera entry probes are consistent with these results. This confirms that the Venus atmosphere is 2 to 100 times drier than previous analyses of entry probe data had indicated.

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